

## Section 6. Information Flow in a Lossless Entropic Network

This section explains how information flows in QIA once the universe is modeled as a lossless entropic network. The central claim is that information is globally conserved, but locally accessible information can change because routing continuously redistributes wave-pattern encoding across nodes, links, and environmental degrees of freedom. Therefore, what appears as “information loss” in ordinary physics is reinterpreted as re-encoding and redistribution.

### 6.1 Conservation law: Total information vs accessible information

In QIA, conservation applies to total information at the closed-universe level. This means that the full network does not destroy information: the complete wave-pattern encoding persists within the universal substrate. However, an observer never accesses the full network. Observers only interact with a restricted domain through limited channels, coarse-grained interfaces, and measurement constraints. For that reason, the amount of accessible information can vary over time, even when total information remains conserved. Routing is the mechanism that explains this distinction. When routing changes, the same information may become encoded into correlations that are inaccessible to a local observer-domain, producing the appearance of loss.

$$I_{total} = \text{constant} \quad (\text{closed universe})$$

$$I_{access} = I_{access}(\mathcal{R}, \kappa, d_E, \text{boundary constraints})$$

This separation between  $I_{total}$  and  $I_{access}$  is essential. It allows QIA to remain information-conserving while simultaneously explaining why decoherence, thermalization, and measurement outcomes look irreversible and information-losing from a local perspective.

## 6.2 Entropic bottlenecks and channel capacity

If the universe is a network, then information-flow is constrained by the properties of links and channels. In QIA these constraints are not only geometric but entropic. Some links are “entropic bottlenecks”: interfaces where maintaining coherent wave-pattern structure requires high entropic cost. When such bottlenecks exist, only a limited amount of structured information can be transmitted stably. To formalize this, QIA introduces an entropic channel capacity,  $C_E(\text{link})$ , which measures the maximal stable throughput of wave-pattern encoding across a link under entropic constraints.

$$\begin{aligned} C_E(\text{link}) : \\ &= \textit{maximal stable wave} \\ &\textit{– pattern throughput under entropic constraints} \end{aligned}$$

When routing attempts to push more structured information than  $C_E(\text{link})$  allows, the network becomes unstable and responds by either scrambling the encoding or re-routing it through alternative paths.

## 6.3 Mixing / scrambling as re-encoding, not destruction

In conventional language, physical processes such as decoherence or thermalization are often described as information loss. QIA rejects this description at the fundamental level. Mixing and scrambling are treated as re-encoding processes. The information is still present, but its encoding becomes distributed into high-dimensional correlations across many degrees of freedom. Locally, this looks like loss because the original wave-pattern codeword cannot be reconstructed without global access. The correct QIA statement is therefore: scrambling hides information in correlations; it does not destroy it.

#### 6.4 Time as perceived update ordering (linked to entropic distance)

QIA also provides a natural interpretation of time. If routing updates are fundamental, then time can be treated as the perceived ordering of routing updates experienced by an observer-domain. In this view, “before” and “after” correspond to successive stabilization steps of the network under constraints. Entropic distance  $d_E$  plays an important role because it quantifies how difficult it is for coherent patterns to remain stable across domains. Larger effective  $d_E$  implies higher entropic separation and therefore a stronger appearance of delay, irreversibility, and causal ordering at the classical interface. Thus, time is interpreted as an emergent ordering index induced by entropic routing dynamics rather than a primitive background parameter.

#### *Perceived time order*

*$\approx$  ordering of routing updates driven by effective  $d_E$*

#### 6.5 Open vs closed cases: closed universe vs open subsystem

Finally, QIA distinguishes between closed and open informational descriptions. The universe as a whole is treated as a closed network, therefore  $I_{\text{total}}$  is conserved globally. However, most subsystems are open: they exchange correlations, constraints, and encoding with the environment. For an open subsystem, accessible information can decrease sharply because routing exports the encoding outward into environmental channels. This is why local subsystems exhibit decoherence and thermalization while the full CUWF network remains lossless in total information content.